

LECTURES

De Potentia Restitutiva,

OR OF

SPRING

Explaining the Power of Springing Bodies.

To which are added some

COLLECTIONS

Viz.

A Description of Dr. Pappins Wind-Fountain and Force-Pump.

Mr. Young's Observation concerning natural Fountains.

Some other Considerations concerning that Subject.

Captain Sturmy's remarks of a Subterraneous Cave and Cistern.

Mr. G. T. Observations made on the Pike of Teneriff, 1674.

Some Reflections and Conjectures occasioned thereupon.

A Relation of a late Eruption in the Isle of Palma.

By ROBERT HOOKE. S.R.S.

LONDON,

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at the Bell in St. Pauls Church-Yard, 1678.

Tab. V.^a Hypothes^{is} Dⁱ Chrⁱ Wren. Equ.



Fig. 19

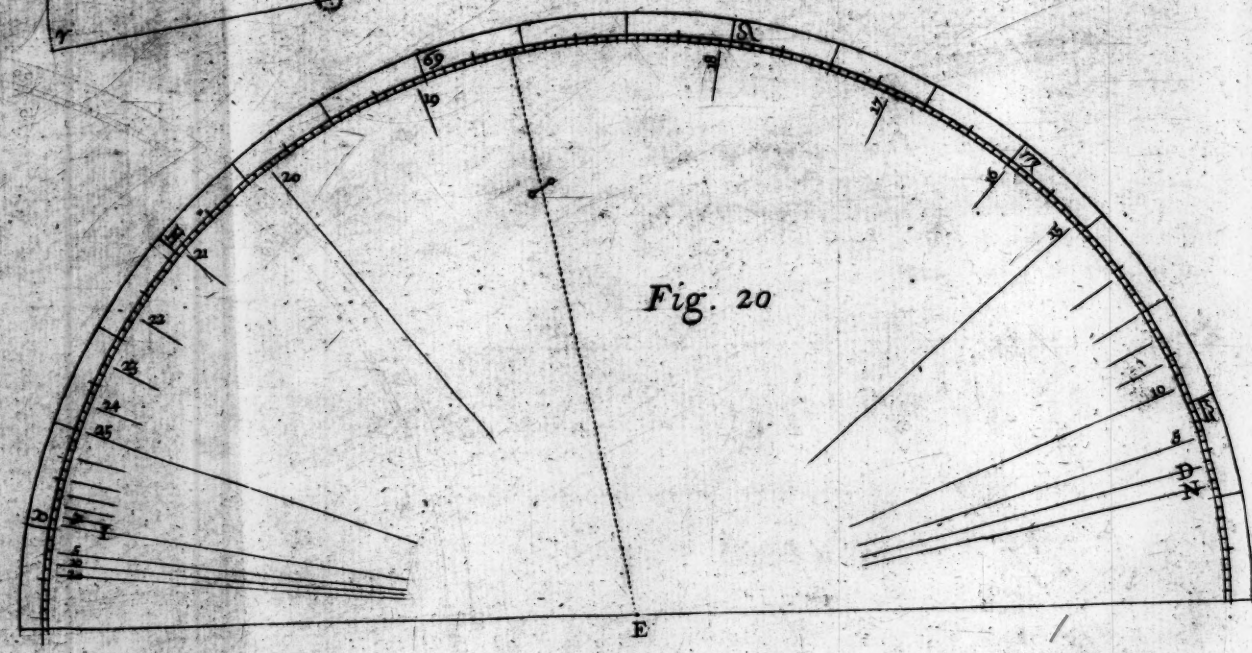
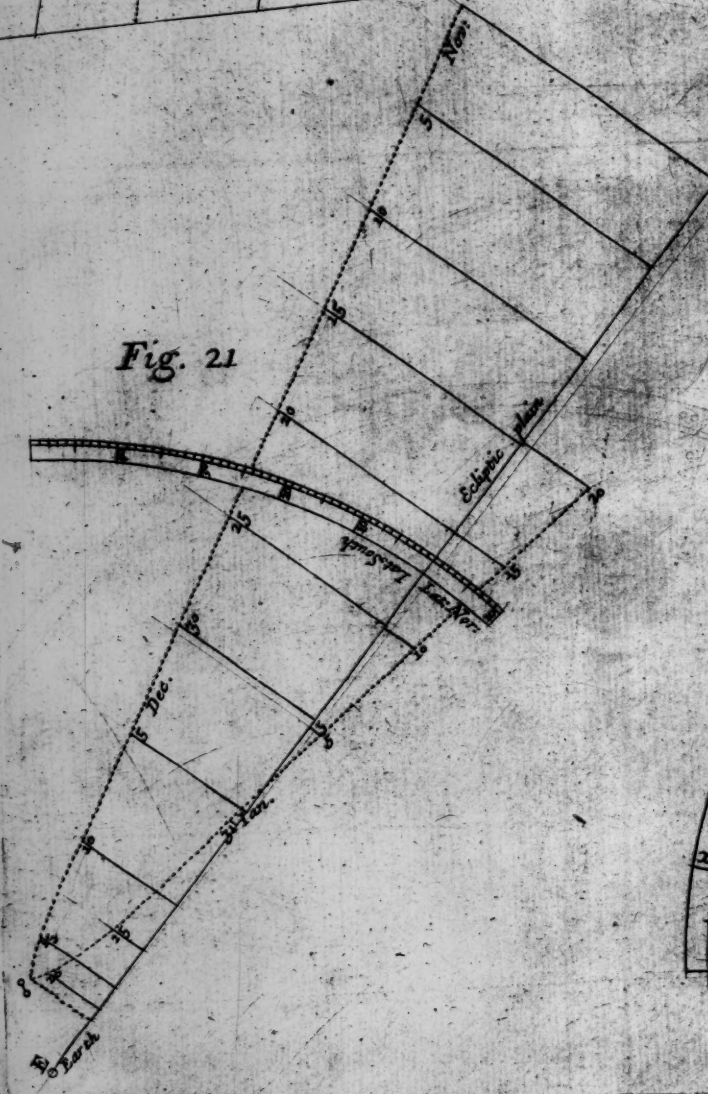


Fig. 20

Fig. 21



Potentia Restitutiva,

OR

SPRING.



The Theory of Springs, though attempted by divers eminent Mathematicians of this Age has hitherto not been Published by any. It is now about eighteen years since I first found it out, but designing to apply it to some particular use, I omitted the publishing thereof.

About three years since His Majesty was pleased to see the Experiment that made out this Theory tried at *White-Hall*, as also my Spring Watch.

About two years since I printed this Theory in an Anagram at the end of my Book of the Descriptions of Helioscopes, *viz. ce i i i n o s s t t n u, id est, Ut tensio sic vis*; That is, The Power of any Spring is in the same proportion with the Tension thereof: That is, if one power stretch or bend it one space, two will bend it two, and three will bend it three, and so forward. Now as the Theory is very short, so the way of trying it is very easie.

Take then a quantity of even-drawn Wire, either Steel, Iron, or Brass, and coil it on an even Cylinder into a Helix of what length or number of turns you please, then turn the ends of the Wire into Loops, by one of which suspend this coil upon a nail, and by the other sustain the weight that you would have to extend it, and hanging on several Weights observe exactly to what length each of the weights do extend it beyond the length that its own weight doth stretch it to, and you shall find that if

B

one

one ounce, or one pound, or one certain weight doth lengthen it one line, or one inch, or one certain length, then two ounces, two pounds, or two weights will extend it two lines, two inches, or two lengths; and three ounces, pounds, or weights, three lines, inches, or lengths; and so forwards. And this is the Rule or Law of Nature, upon which all manner of Resilient or Springing motion doth proceed, whether it be of Rarefaction, or Extension, or Condensation and Compression.

Or take a Watch Spring, and coil it into a Spiral, so as no part thereof may touch another, then provide a very light wheel of Brass, or the like, and fit it on an arbor that hath two small Pivots of Steel, upon which Pivot turn the edge of the said Wheel very even and smooth, so that a small silk may be coiled upon it; then put this Wheel into a Frame, so that the Wheel may move very freely on its Pivots; fasten the central end of the aforesaid Spring close to the Pivot hole or center of the frame in which the Arbor of the Wheel doth move, and the other end thereof to the Rim of the Wheel, then coiling a fine slender thread of silk upon the edge of the Wheel hang a small light scale at the end thereof fit to receive the weight that shall be put therein; then suffering the Wheel to stand in its own position by a little index fastned to the frame, and pointing to the Rim of the Wheel, make a mark with Ink, or the like, on that part of the Rim that the Index pointeth at; then put in a drachm weight into the scale, and suffer the Wheel to settle, and make another mark on the Rim where the Index doth point; then add a drachm more, and let the Wheel settle again, and note with Ink, as before, the place of the Rim pointed at by the Index; then add a third drachm, and do as before, and so a fourth, fifth, sixth, seventh, eighth, &c. suffering the Wheel to settle, and marking the several places pointed at by the Index, then examine the

Distances

Distance of all those marks, and comparing them together you shall find that they will all be equal the one to the other, so that if a drachm doth move the Wheel ten degrees, two drachms will move it twenty, and three thirty, and four forty, and five fifty, and so forwards.

Or take a Wire string of twenty, or thirty, or forty foot long, and fasten the upper part thereof to a nail, and to the other end fasten a Scale to receive the weights: Then with a pair of Compasses take the distance of the bottom of the scale from the ground or floor underneath, and set down the said distance, then put in weights into the said scale in the same manner as in the former trials, and measure the several stretchings of the said string, and set them down. Then compare the several stretchings of the said string, and you will find that they will always bear the same proportions one to the other that the weights do that made them.

The same will be found, if trial be made, with a piece of dry wood that will bend and return, if one end thereof be fix'd in a horizontal posture, and to the other end be hang'd weights to make it bend downwards.

The manner of trying the same thing upon a body of Air, whether it be for the rarefaction or for the compression thereof I did about fourteen years since publish in my *Micrographia*, and therefore I shall not need to add any further description thereof.

Each of these ways will be mote plainly understood by the explanations of the annexed figures.

The first whereof doth represent by A B the coil or helix of Wire, C the end of it, by which it is suspended, D the other end thereof, by which a small Scale E is hang'd, into which putting Weights as F G H I K L M N, singly and separately they being in proportion to one another as 1 2 3 4 5 6 7 8, the Spring will be thereby equally stretch'd to *a, p, q, r, s, t, u, v,*

that is, if F stretch it so as the bottom of the Scale descend to *a*, then G will make it descend to *p*, H to *q*, I to *r*, K to *s*, L to *t*, M to *u*, and N to *w*, &c. So that *x a* shall be one space, *x p*, 2, *x q*, 3, *x r*, 4, *x s*, 5, *x t*, 6, *x u*, 7, *x w*, 8.

The second figure represents a Watch Spring coyled in a Spiral by C A B B B D, whose end C is fixed to a pin or Axis immovable, into the end of which the Axis of a small light Wheel is inserted, upon which it moves; the end D is fixed to a pin in the Rim of the Wheel *y y y y*, upon which is coyled a small silk, to the end of which is fixed a Scale to receive the weights. To the frame in which these are contained is fixed the hand or Index *z*; then trying with the former weights put into the Scale E, you will find that if F put into the Scale E sinks the bottom of it *x a*, then G will sink it to *p*, and H to *q*, I to *r*, K to *s*, L to *t*, and *z* will point at 1, 2, 3, 4, 5, 6, 7, 8 on the Wheel.

The trials with a straight wire, or a straight piece of wood laid Horizontal arc so plain they need not an explication by figure, and the way of trying upon Air I have long since explained in my *Micographia* by figures.

From all which it is very evident that the Rule or Law of Nature in every springing body is, that the force or power thereof to restore it self to its natural position is always proportionate to the Distance or space it is removed therefrom, whether it be by rarefaction, or separation of its parts the one from the other, or by a Condensation, or crowding of those parts nearer together. Nor is it observable in these bodys only, but in all other springy bodies whatsoever, whether Metal, Wood, Stones, baked Earths, Hair, Horns, Silk, Bones, Sinews, Glass, and the like. Respect being had to the particular figures of the bodies bended, and the advantageous or disadvantageous ways of bending them.

From

From this Principle it will be easie to calculate the several strength of Bows, as of Long Bows or Cross-Bows, whether they be made of Wood, Steel, Horns, Sinews, or the like. As also of the *Balista* or *Catapulta* used by the Ancients, which being once found, and Tables thereof calculated, I shall anon shew a way how to calculate the power they have in shooting or casting of Arrows, Bullets, Stones, Granadoes, or the like.

From these Principles also it will be easie to calculate the proportionate strength of the spring of a Watch upon the Fusely thereof, and consequently of adjusting the Fusely to the Spring so as to make it draw or move the Watch always with an equal force.

From the same also it will be easie to give the reason of the *Isochrone* motion of a Spring or extended string, and of the uniform sound produced by those whose Vibrations are quick enough to produce an audible sound, as likewise the reason of the sounds, and their variations in all manner of sonorous or springing Bodies, of which more on another occasion.

From this appears the reason, as I shall shew by and by, why a Spring applied to the balance of a Watch doth make the Vibrations thereof equal, whether they be greater or smaller, one of which kind I shewed to the right Honourable the Lord Viscount *Brounker*, the Honourable *Robert Boyle* Esq; and Sir *Robert Morey* in the year 1660, in order to have gotten Letters Patents for the use and benefit thereof.

From this it will be easie to make a Philosophical Scale to examine the weight of any body without putting in weights, which was that which I mentioned at the end of my description of Helioscopes, the ground of which was veiled under this Anagram, *c e d i i n n o o p s s s t t u u*, namely, *Ut pondus sic tensio*. The fabrick of which see in the three first figures.

This Scale I contrived in order to examine the gravitation of bodies towards the Center of the Earth,

viz. to examine whether bodies at a further distance from the Center of the Earth did not lose somewhat of their power or tendency towards it. And propounded it as one of the Experiments to be tried at the top of the Pike of *Teneriff*, and attempted the same at the top of the Tower of *St. Pauls* before the burning of it in the late great Fire; as also at the top and bottom of the Abby of *St. Peters* in *Westminster* though these being by but small distances removed from the Surface, I was not able certainly to perceive any manifest difference. I propounded the same also to be tried at the bottom and several stations of deep Mines; and *D. Power* did make some trials to that end, but his Instruments not being good, nothing could be certainly concluded from them.

These are the Phenomena of Springs and springy bodies; which as they have not hitherto been by any that I know reduced to Rules, so have all the attempts for the explications of the reason of their power, and of springiness in general, been very insufficient.

In the year 1660. I printed a little Tract, which I called, *An Attempt for the explication of the Phenomena, &c.* of the rising of water in the pores of very small Pipes, Filtres, &c. And being unwilling then to publish this Theory, as supposing it might be prejudicial to my design of Watches, which I was then procuring a Patent for, I only hinted the principle which I supposed to be the cause of these Phenomena of springs in the 31 page thereof in the English Edition, and in the 38 page of the Latine Edition, translated by *M. Behem*, and printed at *Amsterdam*, 1662. But referred the further explication thereof till some other opportunity.

The Principles I then mentioned I called by the names of *Congruity* and *Incongruity* of bodies. And promised a further explanation of what I thereby meant on some other occasion. I shall here only explain so much of it as concerns the explication of this present Phenomenon.

By

By *Congruity* and *Incongruity* then I understand nothing else but an agreement or disagreement of Bodies as to their Magnitudes and motions.

Those Bodies then I suppose congruous whose particles have the same Magnitude, and the same degree of Velocity, or else an harmonical proportion of Magnitude, and harmonical degree of Velocity. And those I suppose incongruous which have neither the same Magnitude, nor the same degree of Velocity, nor an harmonical proportion of Magnitude nor of Velocity.

I suppose then the sensible Universe to consist of body and motion.

By Body I mean somewhat receptive and communicative of motion or progression. Nor can I have any other Idea thereof, for neither Extension nor Quantity, hardness nor softness, fluidity nor fixedness, Rarefaction nor Denstation are the proprieties of Body, but of Motion or somewhat moved.

By Motion I understand nothing but a power or tendency progressive of Body according to several degrees of Velocity.

These two do always counterballance each other in all the effects, appearances, and operations of Nature, and therefore it is not impossible but that they may be one and the same; for a little body with great motion is equivalent to a great body with little motion as to all its sensible effects in Nature.

I do further suppose then that all things in the Universe that become the objects of our senses are compounded of these two (which we will for the present suppose distinct essences, though possibly they may be found hereafter to be only differing conceptions of one and the same essence) namely, *Body*, and *Motion*. And that there is no one sensible Particle of matter but owes the greatest part of its sensible Extension to Motion whatever part thereof it owes to Body according to the common notion thereof: Which is, that
Body

Body is somewhat that doth perfectly fill a determinate quantity of space or extension so as necessarily to exclude all other bodies from being comprehended within the same Dimensions.

I do therefore define a sensible Body to be a determinate Space or Extension defended from being penetrated by another, by a power from within.

To make this the more intelligible, Imagine a very thin plate of Iron, or the like, a foot square, to be moved with a Vibrative motion forwards and backwards the flat ways the length of a foot with so swift a motion as not to permit any other body to enter into that space within which it Vibrates, this will compose such an essence as I call in my sense a Cubick foot of sensible Body, which differs from the common notion of Body as this space of a Cubick foot thus defended by this Vibrating plate doth from a Cubick foot of Iron, or the like, throughout solid. The Particles therefore that compose all bodies I do suppose to owe the greatest part of their sensible or potential Extension to a Vibrative motion.

This Vibrative motion I do not suppose inherent or inseparable from the Particles of body, but communicated by Impulses given from other bodies in the Universe. This only I suppose, that the Magnitude or bulk of the body doth make it receptive of this or that peculiar motion that is communicated, and not of any other. That is, every Particle of matter according to its determinate or present Magnitude is receptive of this or that peculiar motion and no other, so that Magnitude and receptivity of motion seems the same thing: To explain this by a similitude or example. Suppose a number of musical strings, as A B C D E, &c. tuned to certain tones, and a like number of other strings, as *a, b, c, d, e*, &c. tuned to the same sounds respectively, A shall be receptive of the motion of *a*, but not of that of *b, c*, nor *d*; in like manner B shall be receptive of the motion of *b*, but not of the motion
of

of *a, c* or *d*. And so of the rest. This is that which I call *Congruity* and *Incongruity*.

Now as we find that musical strings will be moved by Unisons and Eighths, and other harmonious chords, though not in the same degree; so do I suppose that *the particles of matter* will be moved principally by such motions as are Unisons, as I may call them, or of equal Velocity with their motions, and by other harmonious motions in a less degree.

I do further suppose, A subtil matter that incompasseth and pervades all other bodies, which is the Menstruum in which they swim which maintains and continues all such bodies in their motion, and which is the medium that conveys all Homogenous or Harmonical motions from body to body.

Further I suppose, that all such particles of matter as are of a like nature, when not separated by others of a differing nature will remain together, and strengthen the common Vibration of them all against the differing Vibrations of the ambient bodies.

According to this Notion I suppose the whole Universe and all the particles thereof to be in a continued motion, and every one to take its share of space or room in the same, according to the bulk of its body, or according to the particular power it hath to receive, and continue this or that peculiar motion.

Two or more of these particles joyned immediately together, and coalescing into one become of another nature, and receptive of another degree of motion and Vibration, and make a compounded particle differing in nature from each of the other particles.

All bulky and sensible bodies whatsoever I suppose to be made up or composed of such particles which have their peculiar and appropriate motions which are kept together by the differing or dissonant Vibrations of the ambient bodies or fluid.

According to the difference of these Vibrative motions of the Incompassing bulks. All bodies are more or less powerful in preserving their peculiar shapes.

All bodies near the Earth are compassed with a fluid subtil matter by the differing Velocity of whose parts all solid bodies are kept together in the peculiar shapes, they were left in when they were last fluid. And all fluid bodies whatsoever are mixed with this fluid, and which is not extruded from them till they become solid.

Fluid bulks differ from solids only in this, that all fluids consist of two sorts of particles, the one this common Menstruum near the Earth, which is interspersed between the Vibrating particles appropriated to that bulk, and so participating of the motions and Vibrations thereof: And the other, by excluding wholly, or not participating of that motion.

Though the particles of solid bodies do by their Vibrative motions exclude this fluid from coming between them where their motions do immediately touch, yet are there certain spaces between them which are not defended by the motion of the particles from being pervaded by the Heterogeneous fluid menstruum.

These spaces so undefended by the bodies and Vibrative motion of the particles, and consequently pervaded by the subtil incompassing Heterogeneous fluid are those we call the insensible pores of bodies.

According to the bigness of the bodies the motions are, but in reciprocal proportion: That is, the bigger or more powerful the body is, the slower is its motion with which it compounds the particles; and the less the body is, the swifter is its motion.

The smaller the particles of bodies are, the nearer do they approach to the nature of the general fluid, and

and the more easily do they mix and participate of its motion.

The Particles of all solid bodies do immediately touch each other; that is, the Vibrative motions of the bodies do every one touch each other at every Vibration. For explication, Let A B C represent three bodies, each of

these bodies I suppose to have a Vibrative motion on either side of it, A between D and E, B between E and F, and C between F and G.



I suppose then that B in every one of its Vibrations doth meet A at E, and C at F, and so the motions are continually interchanged: That is, B communicates its motion to A at E, and A at the same time and place communicates its motion to B, which returning to F meets there with C, and communicates its received motion to C, which at the same instant and place communicates its own motion to B, which returns it back to E: So that the Velocity of these bodies is always the same, and each body impresseth on the contiguous bodies such a determinate number of pulses within a certain space of time. Suppose for instance, in every second of time B communicates to A and to C one million of pulses, and hath received as many from each of them, by which means each of them doth preserve its own space of Vibration, according to the power of its Vibration, that neither of the contiguous bodies can enter into it. The extreme particles A and C are repercussed by the motion of the ambient Heterogeneous fluid, whereof though the bodies are of differing magnitudes, yet the body and motion of the one are equivalent to the body and motion of the other, so that whatever the body be less, the motion is quicker; and where the body is bigger, the motion is less. But the Particles of fluid

bodies do not immediately touch each other, but permit the mixture of the other Heterogeneous fluid near the Earth, which serves to communicate the motion from particle to particle without the immediate contact of the Vibrations of the Particles.

All solid Bodies retain their solidity till by other extraordinary motions their natural or proper motions become intermixed with other differing motions, and so they become a bulk of compounded motions, which weaken each others Vibrative motions. So that though the similar parts do participate of each others motions, whereby they endeavour to joyn or keep together, yet do they also participate of an Heterogeneous motion, which endeavours to separate or keep them asunder. And according to the prevalence of the one or the other is the body more or less fluid or solid.

All bodies whatsoever would be fluid were it not for the external Heterogeneous motion of the Ambient.

And all fluid bodies whatsoever would be unbounded, and have their parts fly from each other were it not for some prevailing Heterogeneous motion from without them that drives them more powerfully together.

Heterogeneous motions from without are propagated within the solid in a direct line if they hit perpendicular to the superficies or bounds, but if obliquely in ways not direct, but different and deflected, according to the particular inclination of the body striking, and according to the proportion of the Particles striking and being struck.

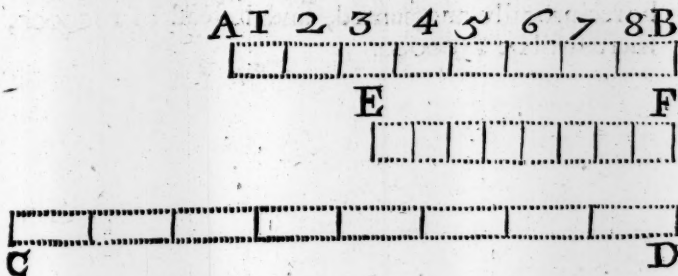
All springy bodies whatsoever consist of parts thus qualified, that is, of small bodies indued with appropriate and peculiar motions, whence every one of these particles hath a particular Bulk, Extension, or Sphere of activity which it defends from the ingress of any other incompassing Heterogeneous body whilst
in

in its natural estate and balance in the Universe. Which particles being all of the same nature, that is, of equal bodies, and equal motions, they readily coalesce and joyn together, and make up one solid body, not perfectly every where contiguous, and wholly excluding the above mentioned ambient fluid, but permitting it in many places to pervade the same in a regular order, yet not so much but that they do wholly exclude the same from passing between all the sides of the compounding particles.

The parts of all springy bodies would recede and fly from each other were they not kept together by the Heterogeneous compressing motions of the ambient whether fluid or solid.

These principles thus hinted, I shall in the next place come to the particular explication of the manner how they serve to explain the Phænomena of springing bodies whether solid or fluid.

First for solid bodies, as Steel, Glass, Wood, &c. which have a Spring both inwards and outwards, according as they are either compressed or dilated beyond their natural state.



Let A B represent a line of such a body compounded of eight Vibrating particles, as 1, 2, 3, 4, 5, 6, 7, 8, and suppose each of those Particles to perform a million of single Vibrations, and consequently of occurrences with each other in a second minute of time,

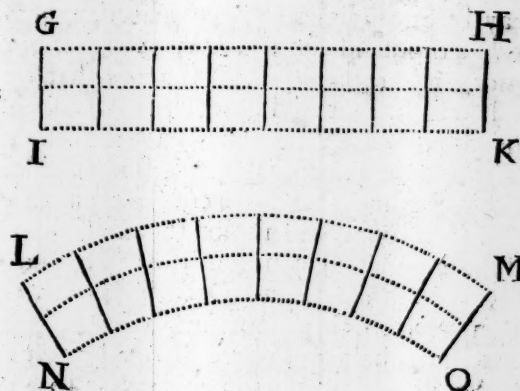
C 3 their

their motion being of such a Velocity impressed from the Ambient on the two extreme Particles 1 and 8. First, if by any external power on the two extremes 1 and 8, they be removed further asunder, as to CD, then shall all the Vibrative Particles be proportionably extended, and the number of Vibrations, and consequently of occurrsions be reciprocally diminished, and consequently their endeavour of receding from each other be reciprocally diminished also. For supposing this second Dimension of Length be to the first as 3 to 2, the length of the Vibrations, and consequently of occurrsions, be reciprocally diminished. For whereas I supposed 1000000 in a second of the former, here can be but 666666 in this, and consequently the Spring inward must be in proportion to the Extension beyond its natural length.

Secondly, if by any external force the extreme particles be removed a third part nearer together than (the external natural force being alway the same both in this and the former instance, which is the balance to it in its natural state) the length of the Vibrations shall be proportionably diminished, and the number of them, and consequently of the occurrsions be reciprocally augmented, and instead of 1000000, there shall be 1500000.

Having

Having thus explained the most simple way of springing in solid bodies, it will be very easie to explain the compound way of springing, that is, by flexure, supposing only two of these lines joyned



together as at G H I K, which being by any external power bended into the form L N N O, L M will be extended, and N O will be diminished in proportion to the flexure, and consequently the same proportions and Rules for its endeavour of restoring it self will hold.

In the next place for fluid bodies, amongst which the greatest instance we have is air, though the same be in some proportion in all other fluid bodies.

The Air then is a body consisting of particles so small as to be almost equal to the particles of the Heterogeneous fluid medium incompassing the earth. It is bounded but on one side, namely, towards the earth, and is indefinitely extended upward being only hindered from flying away that way by its own gravity, (the cause of which I shall some other time explain.) It consists of the same particles single and separated, of which water and other fluids do, conjoynd and compounded, and being made of particles exceeding

exceeding small, its motion (to make its ballance with the rest of the earthy bodies) is exceeding swift, and its Vibrative Spaces exceeding large, comparative to the Vibrative Spaces of other terrestrial bodies. I suppose that of the Air next the Earth in its natural state may be 8000 times greater than that of Steel, and above a thousand times greater than that of common water, and proportionably I suppose that its motion must be eight thousand times swifter than the former, and above a thousand times swifter than the latter. If therefore a quantity of this body be inclosed by a solid body, and that be so contrived as to compress it into less room, the motion thereof (supposing the heat the same) will continue the same, and consequently the Vibrations and Occursions will be increased in reciprocal proportion, that is, if it be Condensed into half the space the Vibrations and Occursions will be double in number: If into a quarter the Vibrations and Occursions will be quadruple, &c.

Again, If the containing Vessel be so contrived as to leave it more space, the length of the Vibrations will be proportionably enlarged, and the number of Vibrations and Occursions will be reciprocally diminished, that is, if it be suffered to extend to twice its former dimensions, its Vibrations will be twice as long, and the number of its Vibrations and Occursions will be fewer by half, and consequently its indevours outward will be also weaker by half.

These Explanations will serve *mutatis mutandis* for explaining the Spring of any other Body whatsoever.

It now remains, that I shew how the constitutions of springy bodies being such, the Vibrations of a Spring, or a Body moved by a Spring, equally and uniformly shall be of equal duration whether they be greater or less.

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I have here already shewed then that the power of all Springs is proportionate to the degree of flexure, *viz.* one degree of flexure, or one space bended hath one power, two hath two, and three hath three, and so forward. And every point of the space of flexure hath a peculiar power, and consequently there being infinite points of the space, there must be infinite degrees of power.

And consequently all those powers beginning from nought, and ending at the last degree of tension or bending, added together into one sum, or aggregate, will be in duplicate proportion to the space bended or degree of flexure; that is, the aggregate of the powers of the Spring tended from its quiescent posture by all the intermediate points to one space (be it what length you please) is equal, or in the same proportion to the square of one (supposing the said space infinitely divisible into the fractions of one;) to two, is equal, or in the same proportion to the square of two, that is four; to three is equal or in the same proportion to the square of three, that is nine, and so forward; and consequently the aggregate of the first space will be one, of the second space will be three, of the third space will be five, of the fourth will be seven, and so onwards in an Arithmetical proportion, being the degrees or excesses by which these aggregates exceed one another.

The Spring therefore in returning from any degree of flexure, to which it hath been bent by any power receiveth at every point of the space returned an impulse equal to the power of the Spring in that point of Tension, and in returning the whole it receiveth the whole aggregate of all the forces belonging to the greatest degree of that Tension from which it returned; so a Spring bent two spaces in its return receiveth four degrees of impulse, that is, three in the first space returning, and one in the second; so bent three spaces it receiveth in its whole return nine

D

degrees

degrees of impulse, that is, five in the first space returned, three in the second, and one in the third.

So bent ten spaces it receives in its whole return one hundred degrees of impulse, to wit, nineteen in the first, seventeen in the second, fifteen in the third, thirteen in the fourth, eleven in the fifth, nine in the sixth, seven in the seventh, five in the eighth, three in the ninth, and one in the tenth.

Now the comparative Velocities of any body moved are in subduplicate proportion to the aggregates or sums of the powers by which it is moved, therefore the Velocities of the whole spaces returned are always in the same proportions with those spaces, they being both subduplicate to the powers, and consequently all the times shall be equal.

Next for the Velocities of the parts of the space returned they will be always proportionate to the roots of the aggregates of the powers impressed in every of these spaces; for in the last instance, where the Spring is supposed bent ten spaces, the Velocity at the end of the first space returned shall be as the root of 19. at the end of the second as the Root of 36. that is, of $19 + 17$. at the end of the third as the Root of 51. that is of $19 + 17 + 15$. At the end of the fourth as the Root of 64. that is of $19 + 17 + 15 + 13$. at the end of the tenth, or whole as the Root of 100. that is as $\sqrt{19 + 17 + 15 + 13 + 11 + 9 + 7 + 5 + 3 + 1}$, equal to 100.

Now since the Velocity is in the same proportion to the root of the space, as the root of the space is to the time, it is easie to determine the particular time in which every one of these spaces are passed for dividing the spaces by the Velocities corresponding the quotients give the particular times.

To explain this more intelligibly, let A in the fourth figure represent the end of a Spring not bent, or at least coun-

counterpoised in that posture by a power fixt to it, and movable with it, draw the line $A B C$, and let it represent the way in which the end of the Spring by additional powers is to be moved, draw to the end of it C at right Angles the Line $C D$, and let $C D$ represent the power that is sufficient to bend or move the end of the Spring A to C , then draw the Line $D A$, and from any point of the Line $A C$ as $B B$. Draw Lines parallel to $C D$, cutting the Line $D A$ in E, E , the Lines $B E, B E$, will represent the respective powers requisite to bend the end of the Spring A to B , which Lines $B E, B E, C D$ will be in the same proportion with the length of the bent of the Spring $A B, A B, A C$.

And because the Spring hath in every point of the Line of bending $A C$, a particular power, therefore imagining infinite Lines drawn from every point of $A C$ parallel to $C D$ till they touch the Line $A D$, they will all of them fill and compose the Triangle $A C D$. The Triangle therefore $A C D$ will represent the aggregate of the powers of the Spring bent from A to C , and the lesser Triangles $A B E, A B E$ will represent the aggregate of all the powers of the Spring bent from A to B, B , and the Spring bent to any point of the Line $A C$, and let go from thence will exert in its return to A all those powers which are equal to the respective ordinates $B E, B E$, in the Triangles, the sum of all which make up the Triangles $A B E, A B E$. And the aggregate of the powers with which it returns from any point, as from C to any point of the space $C A$ as to $B B$, is equal to the Trapezium $C D E B, C D E B$, or the excesses of the greater Triangles above the less.

Having therefore shewn an Image to represent the flexure and the powers, so as plainly to solve and answer all Questions and Problems concerning them, in the next place I come to represent the Velocities appropriated to the several powers. The Velocities then being always in a subduplicate proportion of

the powers, that is, as the Root of the powers impressed, and the powers impressed being as the Trapezium or the excess of the Triangle or square of the whole space to be past above the square of the space yet unpassed; if upon the Center A, and space AC, (C being the point from which the Spring is supposed let go) a Circle be described as C G G F, and ordinates drawn from any point of C A the space to be past, as from B, B, to the said Circle, as B G, B G, these Lines B G, B G, will represent the Velocity of the Spring returning from C to B, B, &c. the said ordinates being always in the same proportion with the Roots of the Trapeziums C D E B, C D E B for putting $AC = a$, and $AB = b$, B G will always be equal to $\sqrt{a^2 - b^2}$, the square of the ordinate being always equal to the Rectangle of the intercepted parts of the Diameter.

Having thus found the Velocities, to wit, B G, B G, A F, to find the times corresponding, on the Diameter A C draw a Parabola C H F whose Vertex is C, and which passeth through the point F. The Ordinates of this Parabola B H, B H, A F, are in the same proportion with the Roots of the spaces C B, C B, C A, then making G B to H B as H B to I B, and through the points C I I F drawing the curve C I I F, the respective ordinates of this curve shall represent the proportionate time that the Spring spends in returning the spaces C B, C B, C A.

If the powers or stiffness of the Spring be greater than what I before supposed, and therefore must be expressed by the Triangle C d e A. then the Velocities will be the Ordinates in an Ellipse as C γ γ N, greater than the Circle, as it will also if the power be the same, and the bulk moved by the Spring be less. Then will the S-like Line of times meet with the Line A F at a point as X within the point F. But if the powers of the Spring be weaker than I supposed, then will C δ e e A represent the powers, and C γ γ O the Ellipsis of Velocity,

Velocity, whose Ordinates $B\gamma$, $B\gamma$, $A O$ will give the particular Velocities, and the S-like Line of time will extend beyond N . The same will happen supposing the body (moved by the Spring) to be proportionately heavy, and the powers of the Spring the same with the first.

And supposing the power of the Spring the same as at first, bended only to $B 2$, and from thence let go $B 2 E A$ is the Triangle of its powers, the Ordinates of the Circle $B g L$ are the Lines of its Velocity, and the Ordinates of the S-like Line $B i F$ are the Lines of time.

Having thus shewed you how the Velocity of a Spring may be computed, it will be easie to calculate to what distance it will be able to shoot or throw any body that is moved by it. And this must be done by comparing the Velocity of the ascent of a body thrown with the Velocity of the descent of Gravity, allowance being also made for the Resistance and impediment of the medium through which it passes. For instance, suppose a Bow or Spring fixed at 16 foot above a Horizontal floor, which is near the space that a heavy body from rest will descend perpendicularly in a second of time. If a Spring deliver the body in the Horizontal line with a Velocity that moves it 16 foot in a second of time, then shall it fall at 16 foot from the perpendicular point on the floor over which it was delivered with such Velocity, and by its motion shall describe in the Air or space through which it passes, a Parabola. If the Spring be bent to twice the former Tension, so as to deliver the body with double the Velocity in a Horizontal Line, that is, with a Velocity that moves 32 foot in a second, then shall the body touch the floor in a point very near at 32 foot from the aforesaid perpendicular point, and the Line of the motion of the body, so shot shall be moved in a Parabola, or a Line very near it, I say very near it, by reason that the

Impediment of the medium doth hinder the exactness of it. If it be delivered with treble, quadruple, quintuple, sextuple, &c. the first Velocity it shall touch the floor at almost treble, quadruple, quintuple, sextuple, &c. the first distance. I shall not need to shew the reason why it is moved in a Parabola, it having been sufficiently demonstrated long since by many others.

If the body be delivered by the Spring at the floor, but shot by some Angle upwards, knowing with what Velocity the same is moved when delivered, and with what Inclination to the Perpendicular the same is directed, and the true Velocity of a falling body, you may easily know the length of the *factus* or shot, and the time it will spend in passing that length.

This is found by comparing the time of its ascent with the time of the descent of heavy bodies. The ascent of any body is easily known by comparing its Velocity with the Angle of Inclination.

Let ab then in the fifth Figure represent 16 foot, or the space descended by a heavy body in a second minute of time. If a body be shot from b , in the Line bf with a Velocity as much swifter than that equal motion of 16 foot in a second, as this Line bf is longer than ab the body shall fall at e ; for in the same space of time that the oblique equal motion would make it ascend from bd to ac , will the accelerated direct motion downward move it from ac to bd , and therefore at the end of the space of one second, when the motions do equal and balance each other, the body must be in the same Horizontal Line in which it was at first, but removed asunder by the space be , and for the points it passeth through in all the intermediate spaces this method will determine it.

Let the Parallelogram $abpq$ then represent the whole Velocity of the ascent of a body by an equal motion of 16 foot in a second, and the Triangle pqr represent the whole Velocity of

of the accelerated descending motion, pb is then the Velocity with which the body is shot, and p is the point of rest where the power of Gravity begins to work on the body and make it descend. Now drawing Lines parallel to agr , as stn , st gives the Velocity of the point t ascending, and tn the Velocity of the same point t descending.

Again, $pbst$ signifies the space ascended, and ptn the space descended, so that subtracting the descent from the ascent you have the height above the Line bd , the consideration of this, and the equal progress forwards will give the intermediate Velocities, and determine the points of the Parabola.

Now having the *Factus* given by this Scheme or Scale, appropriated to the particular Velocity, where-with any body is moved in this or that line of Inclination, it will be easie to find what Velocity in any Inclination will throw it to any length; for in any Inclination as the square of the Velocity thus found in this Scale for any inclination is to the square of any other Velocity, so is the distance found by this Scale to the distance answering to the second Velocity.

I have not now time to enlarge upon this speculation, which would afford matter enough to fill a Volume, by which all the difficulties about impressed and received motions, and the Velocities and effects resulting would be easily resolved.

Nor have I now time to mention the great number of uses that are and may be made of Springs in Mechanick contrivances, but shall only add, that of all springy bodies there is none comparable to the Air for the vastness of its power of extention and contraction. Upon this Principle I remember to have seen long since in *Wadham* Colledge, in the Garden of the learned Dr. *Wilkins*, late Bishop of *Chester*, a Fountain so contrived as by the Spring of the included Air to throw up to a great height a large and lasting stream

stream of water : Which water was first forced into the Leaden Cistern thereof by two force Pumps which did alternately work, and so condense the Air included into a small Room. The contrivance of which Engine was not unknown to the Ancients, as *Hero* in his *Spiritalia* does sufficiently manifest, nor were they wanting in applying it to very good uses, namely, for Engines for quenching fire: As *Vitruvius* (by the help of the Ingenious Monsieur *Claude Perraults* interpretation) hath acquainted us in the Twelfth Chapter of his Tenth Book, where he endeavours to describe *Ctesibius* his Engine for quenching fire. Not long since a German here in *England* hath added a further improvement thereof by conveying the constant stream of water through Pipes made of well tanned and liquored Leather, joyned together to any convenient length by the help of brazen Screws. By which the stream of water may be conveyed to any convenient place through narrow and otherwise inaccessible passages.

The ingenious Dr. *Denys Pappin* hath added a further improvement that may be made to this *Ctesibian* Engine by a new and excellent contrivance of his own for making of the forcing Syringe or Pump, which at my desire he is pleased to communicate to the Publicque by this following Description, which he sent me some time since.

Dr. *Pappins*

*Dr. Pappins Letter containing a
Description of a Wind-Fountain, and
his own particular contrivance about the
forcer of its Syringe.*

Since the Artificial Fountain you have seen at Mr. *Boyles* (which was of my making upon his desire) hath been so pleasing to you as to make you desire to see my description thereof, I cannot doubt but the same will be as grateful also, and well received by the Publick, especially when they shall therein find a remedy for one of the greatest inconveniences of forcing Pumps, which are of so great use for raising of water, and quenching of fires. This was the occasion of my sending you this present description, which would not have been thus prolix had it been only for your self.

In the Figure then A A is the Receptacle or body of the Fountain careful sodered in all places, B B is the Pump, C C the Plug or forcer, D a Pipe in the middle of the Plug, which is perfectly shut and stopped when the Plate E E is forced down upon it, E E is the Plate with a hole in the middle, upon which is sodered a Pipe F, which serves for a handle to move the Plug up and down.

G is a Cock at the top of the Pipe, which serves to moderate the Jetto or stream.

H H is a Valve at the bottom of the Pump, which openeth outward for the passage of the water out of the Pump into the Fountain or Receptacle.

I I is a Cross at the top of the Plug to hinder the Plate E E from being drawn or separated too far
E from

from the hole D in working it to and fro.

KK are two Pins serving both to force down and keep open the Valve H H.

LL are two Appendices soldered unto the top of the Pipe F F, serving both for a handle to the Rod of the forcer, and also to keep down the forcer.

MM are two other appendices or buttons fastned at the top of the two small pillars NN, so as to turn upon the same, and serve to hasp or button down the ends LL of the handle of the forcer that it be not driven up again.

OO is the Basin for receiving the water that falls from the Jet or stream from which it may be forced again into the Fountain or Receptacle.

For charging this Machine the Basin O O must first be filled with water, and then the Pump must be worked to and fro. In doing of which, when the Plug is drawn upwards the water in the Basin runs in through the cross (through which the Rod F F passes,) where finding the hole D open it fills the spaces of the bottom of the Pump; then the Pump being thus filled, the Plug is to be forced downwards, whereby the Plate E E being closely applied to the brims of the hole D hinders the water from returning back again through the same, but is forced through the valve H H into the Fountain A A. And by repeating this operation all the water of the Basin O O is easily forced into the aforesaid Fountain, whereby all the Air that was therein contained is compressed more or less according as more or less water is forced in, and kept in that compression by the valve H H, which hinders the water that it cannot return through the same.

But when you desire to have it return, you force down the Plug hard against the bottom or plate, which by the help of the aforesaid Pins or Appendices KK force, and keep open the valve H H, and the Rod F being kept fast down in this posture by the aforesaid

aforesaid Buttons or Hasps M M, upon opening the Cock G the water returneth through the valve H H, so kept open, through the hole D, and through the whole length of the Pipe F.

This way of putting a valve into the Plug of forcing Pumps will be of great use for all such as serve for supplying Towns with water, and for quenching of fire, as preventing a great inconvenience to which the common Pumps are usually subject from the Air which is apt to be generated within them, which Air upon working the said Pump remaining below the forcer, and by its Expansion when the Plug is drawn upwards, hindring the water from filling the whole Cavity beneath it, and by its Condensation when the Plug is forced downwards, losing a great part of the strength of the force, much of the effect of the said Machine is frustrated.

For preventing of which Inconvenience care is to be taken that the water in all these forcing Pumps be admitted by the top thereof as in the present Machine, whereby whatever Air shall be generated below the Plug, will readily rise into the hole D as being the highest place next the Plate E E, from whence when by the drawing up of the Plug the Plate is lifted from the brims of the hole D the Air will readily slip up, and the water as readily descend and fill all the parts of the Pump below the Plug. As I have often experimented in this present Machine.

Some Persons may object against these kind of valves, as supposing the pressure of the water to be on the wrong side thereof. But it is easie to be noted that this objection is groundless, since it is the same thing whether the Plate be pressed against the Rim of the valve, or the Rim of the valve against the plate. In common valves the Pressure of the water forceth the Plate against the Rim: But in this the Rim against the Plate; for the remaining solid Rim of the valve, being made thrice as big as the hole or Cavity thereof,

the pressure of the water against that Rim forceth the said Rim against the Plate in the middle three times harder than if the pressure of the water lay only on the plate of the value, the same would be pressed against the Rim.

To this Discourse of an Artificial Fountain I thought it not improper to add an ingenious Discourse of M. *James Young* of *Plimouth* containing his own Observations and Opinion concerning natural Fountains and Springs.

SIR,

HAVING now gained time, from my other avocations, I have drawn up those observations: I told you I had made in my travels, which had confirmed in me the opinion of my Lord *Bacon*, that Fountains and Springs were the Percolation of the Sea; not (as your self, Mr. *Ray*, &c. do assert) from the rains descent into the Earth, I now represent them to your consideration, rather as an Apology (because they seem rational) to excuse, than Arguments to justify and avow the presumption of my dissent.

The first shall be the Phænomena, I observed at *Isle de Mayo*, which lieth in the Torrid Zone, about thirteen degrees and 30 minutes, North from the Equator. It's about six Leagues long, and four broad, the wind bloweth constantly North East, or thereabout, and without rain, except three weeks in *July*, when it hath many showers; I here send you a Map of the Island, as exactly as I could draw it. I was there two Voyages, and each remained a full month, the best part of which I spent in hunting, and ranging the Island; there runneth through the middle of it a Rivulet, of very pure water; It takes its rise
from

from the bottom of two Hills, which lie on the North East end; The stream at the place marked D, is about fourteen foot wide and two deep; other than which there is no fresh water on the whole Island, except what our people dig out of the sand between the Ocean and the salt Pond.

The said Pond is in a large Bay, at the West side of the Island, which hath from one point to another a bank of Sand, about two or three foot above water, covering the Bay like a string to a Bow, the said bank in the Flemish Road is about 150 foot wide, at the English Road it is as broad again; there is never any sensible ebbing or flowing of the Sea, only at full Moons, or a day before. It riseth in high Billows, which break over the Bank, at the North end of the Pond, where it is lowest: By which means the Pond is replenished with water, which condenseth into Salt in two days.

The Sand dividing the said Pond and the Sea is very fine and loose. Now because the before-mentioned Rivulet disembogues far from the Roads at an inconvenient place for Boats, they are constrained to dig Wells, in the midst of the bank of Sand, between the Pickle of the salt Pond and the Sea, the manner thus: They first dig a pit about eight foot deep, and therein lay two Hogsheds, the one on the top of the other, the head out of both save the lowermost of the deepest; the sides of both are also full of Gimlet holes, and the sand laid close to them: After twenty four hours they have three or four foot of very clean water in them, which being dipped out, you plainly see the new water strainingly through those holes in the sides of the Cask: After which, in a days time, one man attending it, may draw about ten Hogsheds or more of water, a little tasting of Salt, not so much but that it is drinkable, and very fit to boyl meat in, and is used by those that come there to load Cattle, for their

common drink. I have in the Map placed the Sign O where our Well was made.

The next observations, pertinent to this subject I made at the Island *Lipari*, near *Sicily*, about sixteen Leagues from *Messina*; it is famous for the best Raisins in the *Mediterranean*; there is on it a large Castle, a small Town, many Vineyards, and about one hundred Families, besides some *Religiose*. I judge it wants a fifth part of the bigness of the *Isle de Mayo*, it is mostly very high Land, especially one Mountain, on which stands a Watch Tower, whence a man may see a monstrous distance at Sea, as is confirmed by *de Ruyter*. In the relation he gives the States of *Holland*, wherein he tells them, that from that place they discerned the French Fleet's approach long before they could from any other part, either of their own or the other Island. I am sure it is much higher than either that at the *Isle de Mayo*, or any I have seen in *England*, and yet on this fair fruitful Island springs not one drop of water, the Inhabitants storing themselves with rain, which falling very frequently, they are careful to preserve in Cisterns, divers essays have been made in the most promising part of it to find Springs by digging Wells, one of those which I saw was without doubt the deepest in *Europe*, I remember not the exact profundity as they related it, but I have not forgot, that throwing in a stone it was long ere it got to the bottom, and then returned such a noise as it had been the discharge of a Musquet.

The cause of this driness was by the people thought to be subterranean heats, absorbing the water, but no such thing appearing, to the sense of those that digged the Wells, I gave no faith to that persuasion; they fancy such heats partly from the want of water, but mostly because the four adjacent Islands, *Stromboli*, *Vulcano*, *Vulcanella*, and *M. Ætna*, are constantly burning, and very near them.

The

The obvious earth of this place is loose, and in all apparent qualities very good, but by the heaps that had been thrown up, in digging the Wells, I saw the inferiour earth was clammy, or like clay, that had some greasie gummous matter commixed, This the Religious told me was the very kind of Sulphur which constantly boyled out of the burning Cranny on *Vulcanella*; and wherewith all those Islands abound- ed, not excepting their own, though it were not yet kindled.

For my third observation, I will go no farther than the place of my present abode, *Plimmouth*, in which on a kind of Piazza, commonly called the *New-key*, (a plat of ground got in from the Sea) is a Well, which (before the ever famous Sir *Francis Drake* by cutting a Rivulet of thirty miles procured us water in great plenty) was of common use, having (as at this day) a Pump in it; about seven years since (be- ing before the Key was enlarged) the Well was not above eight foot from the edge thereof, over which the Sea would frequently flow, when a high out- wind and a Spring Tide concurred, I say this Well, though so near the Sea, yieldeth clean water, and as sweet as a mixture of three parts fresh and one of salt water would be. About an hundred yards from that, on ground a little rising, is a very large Well, which supplieth three or four Brew-houses, by whose drink it is evident that the water hath not wholly quitted its salt. It is to be noted, that *Plimmouth* lieth on a Peninsula three miles long, and two broad, the Isth- mus about two thirds of a mile wide, and not very high from the surface of a full Sea. There are many Wells in it, those near the Sea are saltish, those far- ther from it the less so.

My fourth observation I take from the late famous French Traveller Monsieur *Taverner*, who in his first Volume, discoursing of the Coast of *Coromandel*, &c. he saith they there want fresh water, and are con- strained

strained to make pits of two foot deep in the sand by the Sea to find it.

The fifth observation, and which I would call the most significant, were I assured of its truth, I had from a very ingenious Chirurgeon, who had used the *West Indias*, that there is in that Sea an Island called *Rotunda*, of a figure agreeable to its name, which, though very small, hath on it, arising in the middle, a Spring of a very large stream of water, at which our Ships frequently furnish themselves in their Navigation, he affirmed that it raineth there but once a year, as at the *Isle de Mayo*; saying withal, that the Island is so short of a proportion big enough for the stream, that if it constantly rained, it could not be supply enough to maintain so large an Efflux.

My sixth and last, is the relation of Dr. *Downes* concerning *Barbadoes*; viz. that all their Springs were formerly very near the Sea; that up in the Country they supplied themselves from the rains by digging pits in the earth, able to contain great quantities, and there preserving it; which they did a very long time (the rains being there as unfrequent as at the *Isle de Mayo*) and that without any sensible diminution by penetrating and descending into the earth; and to prevent the loss thereof by the exhalations of the Sun they covered it with leaves, &c. but that now by digging deeper they find Springs so plenty that no Plantation is without one.

From all these observations the following confectaries do mechanically result.

From the first it appeareth that some Springs have manifestly their source from the Sea; that sand sweetens transcolated Sea-water, and that even pickle strained through it loseth much of its saltness thereby, all which is evident from the Well therein mentioned, whose water could not possibly be other than what soaked in from the Pond and the Ocean.

Hence

Hence also is manifest, that constant and large Fluxes of water may be made for eleventh months without rain to refill the subterranean Cisterns, supposed by you to supply them; this appears from the River running through the Island, by whose banks I found (it being *April* when I was there, at which time they had been ten months without rain) thst after their showers it could run but little larger than it did after so tedious a want of them. I had forgot to intimate in the relation, that those two Hommets, A. are craggy Rocks, whereon live a great number of Goats, and are consequently very unfit, if not incapable, either to receive, or contain the Magazine for the supply of the Rivulet.

From the second it is manifest, that higher Mountains of earth, and consequently more likely to receive and contain sufficient quantity of rain-water to beget and supply Springs and Rivers have not always that effect, although there was one great advantage more added here, *viz.* a clammy tyte earth in the bottom to make the supposed Cistern the better able to contain the store. I say, that frequent rain to fill, high Mountains to contain, loose pervious earth to receive, and a well luted bottom to support and retain (being all the qualifications and circumstances supposed necessary to make and continue Springs according to the modern Hypothesis) though all here concurred, did notwithstanding fail of producing that effect.

From the same it is also manifest, that where Springs fail, without want of the causes that Hypothesis supposeth necessary to produce them, the occasion hath been from an apparent defect in the other (that is the imperviousness of the earth through which the water must pass before a Spring can be produced) both these appeared at *Lipary*, where the general effect a Spring or fountain was wanting, together with the causes of our Hypothesis, though those of the other were

F manifestly

manifestly existent, and with all the advantages necessary: It seeming to me a very rational conjecture, that the greasie clammy Sulphur, wherewith that earth was impregnated, did by oppilating it hinder the insinuation of the Sea into it.

From the third observation you have the first deduction confirmed, *viz.* That Springs are sometimes manifestly from the Sea; That earth sweetens Sea-water by Percolation; And that the nearer Springs are to the Sea, the more they retain of their pristine saltness, and lose it by sensible degrees, as they insinuate farther through it.

By the fourth the same is confirmed.

The fifth proveth, that large streams flow without any possibility of being supplied by rain, both for want of such rain, and of dimensions to receive and contain it.

The sixth doth evidence, that rain doth not penetrate the Surface of the earth, even in a very dry parched Country, and in the Torrid Zone, and yet that Springs are under it, which at once proves ours, and refutes the other opinion; the former appears by the water in those made Ponds, lying there for a long time without any sensible loss thereof by its leaking into the earth: The later by the Wells near the Sea, and those found since under that impervious Land.

He that is not altogether a stranger to the weight, pressure, and Elasticity of the air, the ascension of liquors through Filters, and some other resembling Phænomena, would not account the like motion of the transcolated water to high hills, to be an objection of any force against this Hypothesis, but sure such solutions are no less beyond my ability than design.

Finding I have Paper enough left, I will presume to trouble you with one rare appearance more, that occurred to one Mr. *Brassey* of this Town, an aged
and

and very fat man, who by taking Spirit of Vitriol in his mornings draughts (to which he was advised as a remedy to assuage the exuberance of his belly) found that it had no effect on his body ; but that a bundle of Keys, which he used to carry always about him, and that wonted to be very smooth and bright, of a sudden became black and rusty, though he never handled the Spirit, nor carried it in his pocket, so that we concurred in opinion that the sudorous Effluvia of his body, impregnated with the Acid Spirit, had occasioned it.

If so, It's very wonderful, that so small a quantity thereof, when diluted with so much juice as is contained in such a corpulent man, should even in steam and the insensible Emanations make impressions on smooth Iron, mauger the perpetual attrition, by carrying them in his Pocket, whereby such an effect (one would think) should be prevented, or soon rubbed of. — I was going to make some reflections on this notable accident, but I consider, &c. —

Plimouth
May 5. 1678.

James Young.

THE Original of Springs is that which hath exercised the Pens of many learned Writers, and very various have been the conjectures concerning it. But amongst all I have met with I conceive none more probable than that which seems to fetch its original from the History of the Creation mentioned in Holy Writ; that is, that there is a Magazine of waters above as well as a Receptacle of waters upon or beneath the Surface of the Earth: And that the Air is that Firmament which separates between the upper and lower waters, and between these two is the circulation of waters (or bloud of the Microcosm, if I may so call it) performed. The water being sometimes by a particular constitution of the Air assisted by heat, rarified and separated into minuter parts, and so reduced into the form of Air, and thereby being divided into Particles really smaller than those of the air in compassing, and agitated with a greater degree of motion, they take up more space, and so become lighter than the Ambient, and are thereby elevated and protruded upwards till they come to their place of poise or Equilibrium in the Air: At other times by a differing constitution of the Air and deficiency of heat they lose their agitation, and many of them again coalesce, and so having less motion they condense and revert into water, and so, being heavier than the incompassing Air, descend down again to the Earth in Mists, Rain, Snow, Hail, or the like.

That there is such a Circulation I think there is none doubts, but still it remains a difficulty (with those persons that grant this) that all Rivers and Springs should have their original from the water that falls or condences out of the Air.

To persuade such persons it may not possibly be unsuccessful to mention:

First,

First, That the great inundations or overflowing of Rivers manifestly proceed either from the Rain that immediately falls, or from the melting of Snow or Ice that hath formerly fallen on the more eminent parts of Mountains; to confirm which, Histories enough might be brought were it necessary of *Nilus, Niger, &c.*

Secondly, That it hath been observed and computed that *communibus annis & locis*; there falls water enough from the Sky in actual Rain, Snow, or Hail upon the Surface of *England* to supply all the water that runs back into the Sea by the Rivers, and also all that may be supposed to evaporate; nay, though the quantity of the first be supposed twice as much as really it is. This I have been assured by those that have both experimented and calculated it.

Thirdly, That there is not yet certainly (that I know or have heard of) any other way of making salt water fresh, but by Distillation; which, had there been such an Art, it would in all probability have been made use of, and so there is little probability that the Springs at the top of a high Hill should proceed from the Sea-water strained through the earth. But were there such a filtration known I hinted in my Attempt, published *anno 1660* about Filtration, how somewhat of that kind might be explained.

Fourthly, That this Operation is constantly and most certainly performed by Nature both in exhaling and drawing up fresh steams and vapours from the Sea, and all moist bodies, and in precipitating them down again in Rain, Snow, Hail, but of the other we have no certainty.

Fifthly, I have observed in several places where a Tree hath stood upon an high Hill, singly and particularly at the brow of Box Hill near *Darking* in *Surrey*, that the body of the Tree is continually wet, and at the root some quantity of water, which is always soaking and gliding down from the Branches and body of the Tree, the leaves, sprigs, and branches of

the said trees collecting and condensing continually the moyst part of the Air, the same being indeed a true and lively representation of a River. Nor has it been my observation alone, but the same is mentioned by divers Authors: And it is affirmed by some Authors, that there are some Islands in the Torrid Zone which have no other water in them than what is condensed out of the Air by the Trees at the tops of the Hills, and converted into drops of Rain.

Sixthly, That it is generally observed, wherever there are high Hills there are generally many Springs round about the bottoms of them of very fresh and clear water, and often times some which rise very near the tops of them, which seems to proceed from their great elevation above the other plain superficial parts of the earth, whereby the Air being dashed and broken against them, they help to condense the vapours that are elevated into the higher and cooler Regions of the Air, and so serve like Filtres to draw down those vapours so condensed, and convey them into the Valleys beneath, And hence it is very usual in Countries where there are high Hills to see the tops of them often covered with clouds and mists, when it is clear and dry weather beneath in the Valleys. And in the passing through those clouds on the top I have very often found in them very thick mists and small rain, whereas as soon as I have descended from the higher into the lower parts of the Hills, none of that mist or rain hath fallen there, though I could still perceive the same mists to remain about the top. Consonant to this Observation was one related to me by an ingenious Gentleman Mr. G. T. who out of curiosity with other Gentlemen whilst he lived in the Island of *Teneriff*, one of the *Canaries* made a journey to the top of that prodigious high Mountain, called the *Pikc*. The substance of which (to this purpose) was, that the *Caldera* or hollow Cavity, at the very top

top thereof he observed to be very slabby and moyst, and the earth to slip underneath his feet, being a very moyst soft Clay or Lome like mortar. And farther, that at a Cave, not far from the top, there was a great quantity of very fresh water, which was continually supplied, though great quantities of Ice were continually fetch'd from thence, and carried down into the Island for cooling their Wines. Consonant to which Observation was that which was related to me by the Inquisitive Mr. *Edmund Hally* made in *St. Helena* whilst he stayed there to observe the places of the Stars of the Southern Hemisphere, in order to perfect the Cœlestial Globe. Having then placed himself upon one of the highest Prominences of that small Island, which he found to be no less than 3000 foot Perpendicularly above the Surface of the Sea next adjoining, supposing that might be the most convenient place for his designed observation; He quickly found his expectation much deceived as to that purpose for which he chose it; for being gotten so high into the Air the motion of it was so violent as much to disturb his Instruments; but which was more, he found such abundance of mists and moysture that it unglued the Tubes, and covered his Glasses presently with a Dew; and which was yet more, the fogs and mists almost continually hindred the sight of the Stars. But upon removing to a lower station in the Island he was freed from the former Inconveniences.

I could relate many Histories of this nature, whereby it seems very probable, that not only Hills, but Woods also, do very much contribute to the condensing of the moysture of the Air, and converting it into water, and thereby to supply the Springs and Rivulets with fresh water: And I am confident, whosoever shall consider his own observation of this nature, and compare them with this Theory, will find many arguments to confirm it. However, *Nullius in verba,*

verba, Let Truth only prevail, and Theories signifie no further than right reasoning from accurate Observations and Experiments doth confirm and agree with them.

Having thus delivered here somewhat of my own thoughts concerning Springs and Rivers, finding among some of my Papers a Relation, wherein a very strange subterraneous Cistern is mentioned, I have here subjoyned it as I received it from Mr. *Thomas Alcock* from *Bristol* who together with Sir *Humphry Hooke* was by whilst Captain *Samuel Sturmy* made this inquiry, and who by interrogatories made to him, penn'd this Relation for him as it follows verbatim.

IN pursuance of His Majesties Commands to me at the presenting of my *Mariners Magazine*, I have with much diligence, some charge and peril endeavoured to discover that great Concavity in the earth in *Glocestershire*, four miles from *Kingrode*, where His Majesties great Ships ride in the *Severn*. And I find by experience that what has been reported of that place is fabulous, whilst I thus describe it.

Upon the second of *July 1669*. I descended by Ropes affixt at the top of an old Lead Oare Pit, four Fathoms almost perpendicular, and from thence three Fathoms more obliquely, between two great Rocks, where I found the mouth of this spacious place, from which a Mine-man and my self lowerd our selves by Ropes twenty five Fathoms perpendicular, into a very large place indeed, resembling to us the form of a Horse-shoo; for we stuck lighted Candles all the way we went, to discover what we could find remarkable; at length we came to a River or great Water, which I found to be twenty fathoms broad, and eight fathoms deep. The Mine-man would have perswaded me, that this River Ebbd and Flowed, for that some ten fathoms above
the

the place we now were in we found the water had (sometime) been, but I proved the contrary by staying there from three hours Floud to two hours Ebb, in which time we found no alteration of this River ; besides, it's waters were fresh, sweet, and cool, and the Surface of this water as it is now at eight fathom deep, lies lower than the bottom of any part of the *Severn* Sea near us, so that it can have no community with it, and consequently neither flux nor reflux, but in Winter and Summer, as all *Stagna's*, Lakes, and Loughs (which I take this to be) has. As we were walking by this River thirty two fathoms under ground, we discovered a great hollownes in a Rock some thirty foot above us, so that I got a Ladder down to us, and the Mine-man went up the Ladder to that place, and walk'd into it about three-score and ten paces, till he just lost sight of me, and from thence chearfully call'd to me, and told me, he had found what he look'd for (a rich Mine ;) but his joy was presently changed into amazement, and he returned affrighted by the sight of an evil Spirit, which we cannot perswade him but he saw, and for that reason will go thither no more.

Here are abundance of strange places, the flooring being a kind of a white stone, Enameled with Lead Oare, and the Pendent Rocks were glazed with Salt-Peter which distilled upon them from above, and time had petrified.

After some hours stay there, we ascended without much hurt, other than scratching our selves in divers places by climbing the sharp Rocks, but four days together after my return from thence I was troubled with an unusual and violent Headach, which I impute to my being in that Vault. This is a true account of that place so much talk't of, described by me

Samuel Sturmy.

G

Having

Having given you a Relation of something very low within the bowels of the Earth, I now shall add,

An account of a Journey made to the highest part of the earth by my Ingenious Friend Mr. G. T. as I collected it out of the Memorials which he writ at the time of making it; The particulars whereof were,

That August the twentieth, 1674. about Nine in the morning, in company with Dr. Sebastian de Franques, Mr. Christopher Francis, Mr. Thomas Proudfoot, together with a Guide, and two other men with hories to carry themselves and necessary provision for the Journey, he set out from

They passed up a Hill, which was very steep, till they came to the *Pinal* or Wood of Pines. This Wood lieth very high in the Island, and extendeth it self from one end of the Island to the other, and is in many places of a great Breadth, and is very frequently covered with a *Bruna*, fog, or mist, which is so thick as to darken and hinder the appearance of the Sun through it, and so moist as to make one wet in passing through it.

Through this Wood they rode by a pretty steep ascent near two Leagues, crossing it till they came to the further or side, where alighting they rested themselves under a Pine, and Dined. And the fog, which had accompanied them through the whole Wood, here left them, and the Sun appeared.

From hence they parted about one in the Afternoon, and after an ascent of about half a mile of very bad stony way they came to a sandy way, which for about the length of a League was pretty plain; but then they began to ascend a sandy hill, which for half a League farther was pretty steep, which having passed they arrived at the foot of the *Pike*.

Here they alighted, and then rested themselves for some time, then taking horse again, they began to

to

to ascend the *Pike* it self. This part of it was so steep that the way up it is made by several turnings and windings to and fro to ease and alleviate the steepness of the ascent, which were otherwise unpassable for horses. All this part seems to be nothing else but burnt stones and ashes, which may have formerly tumbled down from the higher parts of the *Pike*.

At this place they alighted, and unloaded their horses of the Provision of Victual and water which they were forced to carry with them for their own accommodation, as also of the Provender for their horses. And presently set themselves to provide against the inconveniences of the ensuing night by getting together in the first place a good quantity of the wood of a small shrub, called *Retamen*, not much unlike our English Broom, which grows there pretty plentifully, and when dry burns very well; then, having gotten wood enough, they endeavoured to shelter themselves against the piercing cold wind by heaping up a wall of stones on the windward side, and making a good fire of the dry shrubs they had collected to warm themselves.

But so furious was the wind which came pouring down from each side of the Mountain that it blew the smoak and ashes into their eyes, and forced them (though much to their Regret by reason of the extreme piercing coldness of the Air) to remove their fire farther off. And to keep themselves as warm as they could by lying down upon the ground very close together. Thus they passed the night together as well as they could, but with very little sleep, partly by reason of the cold, and partly for the continual expectation they had of the moment when their Guide would call them to be mounting up the *Pike*, which is usually about two or three hours before day, to the end that they may get up to the top before the rising of the Sun. For at the rising of the Sun the Air is the most clear, and all the Islands of

the *Canaries* round about may be then plainly discovered.

But at two a clock, when they should have been on their Journey, the wind continued to blow with such violence, that their Guide would by no means venter to go up for fear least in the climbing up some steep places the wind should encounter any of them, and hurl them headlong down, so that they were forced to continue and shelter themselves in their bad Lodgings till the Sun arose, and had got some mastery of the wind.

About six a clock therefore they set forwards on their enterprize, having first taken each of them his dish of Chocolate to fortifie their stomachs the better against the cold, so with their Bottle of Strong-water in their Pockets, and Staves in their hands, they began to mount the *Pike*, the way being just such as they had passed the night before, but much more steep, and continued on till they came to the *Mal pays*, or stony way, which may be about half a mile from the place where they lay; This stony way lieth upon a very steep ascent, and is compounded of abundance of stones which lie hollow and loose, some of them of a vast prodigious bigness, and others of them smaller, in such manner as if they had been thrown up there by some Earthquake, as the Author conjectures with very great probability. In the climbing up these stones they took great care in placing their steps on such of them as were more firm for fear of slipping or tumbling so as to break their Legs or Arms.

With this difficulty they ascended till they came to the Cave which he conjectures to be about three quarters of a mile distant from the beginning of the stony way.

At this Cave they found several persons who were come thither to get out Ice to carry down into the Island, some of which were below in the Cave,
digging

digging Ice which was very thick, others remained above. They found the mouth of the Cave about three yards high, and two yards broad; and being all of them desirous to descend into it, by a Rope fastned about their bodies under their armpits they were all one after another let down into it till they came to set their feet upon the Ice, which is about sixteen or eighteen foot from the mouth.

The Cave is not very large, but full of water and Ice, which at the time when they were there lay about a foot under the Surface of the water, though the men that usually go thither said that at other times they found the Ice above the water, which makes many to suppose that it ebbs and flows by means of some secret entercourse that it may have with the Sea, they averring that they have seen it emptying of it self.

But this Gentleman so soon as ever he came down fixt his eye upon a stone that lay just above the Surface of the water, and observed very diligently but could not in all the space that he staid there, which was half an hour, find it either increase or diminish, which makes him believe that the fulness or emptiness of the water may rather proceed from those thick fogs and mists which are generally on the top, and which hinder the *Pike* from being seen sometimes for twenty, thirty, nay, forty days together, except only just at the rising or setting of the Sun, though at some other times it happens also that the Air is clearer, and the *Pike* may be seen perhaps for a month together. From these mists he conceives at some times much water may be collected at the upper parts of the *Pike*, and soaking down may not only supply, but increase the water in the Cave; and consonant to this Hypothesis he observed whilst he was there, that there was a continual gleting and dropping of water in six or seven places from the sides of the Cave, which droppings he supposes may be greater or less according as

those fogs do more or less encompass it, or stay about it a longer or shorter time; He judges also that there may be some other more secret ways both for the conveying water into and out of the said Cave than those droppings, but supposes them to proceed from the aforesaid fogs. Hence he concludes when the Air is clear, and none of those fogs condensed about the Hill, the water in the Cave must necessarily decrease. And that which confirmed him the more in this opinion was that when he came to the very top of the *Pike*, he found the earth under him so very moist, that it was like mud or mortar, and might be made into Paste as by experiment he found which he conjectures could no ways be caused by the wind or clear Air, which is rather drying and consuming of moisture, but must proceed from the fogs or mists which are above the very top of the *Pike*.

He further took notice in the Cave that upon the sides and top thereof there grew a snow-white furring like Saltpeter, which had a kind of saltish taste, some of which he gathered and brought back with him to *England* to have it examined.

After about half an hours stay in the Cave, which they found warmer than without in the open Air, they were all pulled up again, and proceeded forward in their Journey by continuing to clamber up the stony way, which lasted till they came to the foot of that part of the Mountain which is called the Sugar-loaf, by reason that at a distance from the Island it appears of that shape, as it doth also, even when you are at it. The distance of this place from the Cave they judged to be about half a mile, but the way much more steep and ascending than the former part of the stony way, and extreme troublesome to pass; their feet sinking and slipping down again almost as much as they could stride upwards, so that they concluded it the most painful of all; however, persisting in their endeavours, after many times resting themselves, they gained

gained the top, which they conceive might be about half a mile higher.

The very top they found not plain, but very Rocky and uneven, and in the middle thereof a deep hole; the outside of this top this Gentleman conceived might be about a quarter of a mile round about on the outside.

This hole he conceived to be the mouth of a *Vulcano* which hath formerly been in that place, for even at that time whilst they were there much smoak ascended out of several holes and chinks of the Rocks, and the earth in divers parts was still so very hot as to be very offensive to their feet through their shoes, and he observed Brimstone thrown up in several places, of which he collected some, and brought back with him to *England*.

From this place may be seen in a clear day all the six adjacent Islands, but the weather being then somewhat thick and hazy, they could discover none but the grand *Canaries*, *Palm*, and the *Gomera*, which last, though distant near eight Leagues from the bottom of the *Pike* seemed yet so near unto them as if it had been almost under them. The rest of the Islands they could discover whereabout they lay by means of a kind of white cloud hanging on them, but they could not discern the Islands through those clouds.

Here they tried their Cordial Waters which they carried in their Pockets, but found them not to abate of their usual strength, and become cold and insipid as fair water, as several had positively averred to him that they had found it, but he conceived them to be very much of the same nature and strength that they were of before they were carried up, which he supposes to be by reason of their arriving at the top so late.

After they had stayed on the top about an hour, and satisfied themselves in observing such things as they were able, they descended again with very much facility,

facility, and came to the *Stancia* about eleven of the clock, where they dined, and thence about one in the Afternoon set forwards for the *Villa*, where they arrived that afternoon about five that Evening.

After their return they found their faces (by reason of the heat of the Sun, and the parching subtil wind) to cast their skins.

He did not measure the Perpendicular height of the Hill himself, but says that he hath been informed by divers skilful Seamen, (who by their best observation have taken the height of it) that it is between three and four miles perpendicularly above the Sea.

IN this Relation it is very remarkable:

First, that this prodigious high Hill is the Product of an Earthquake, and seems heretofore to have been a *Vulcano*, or burning Mountain, like those of *Ætna*, *Vesuvius*, *Hecla*, &c. though at present it hath only fire enough left to send forth some few sulphureous fumes, and to make the earth of the *Caldera* or hollow pit at the very top thereof in some places almost hot enough to burn their shoes that pass over it. And possibly in succeeding Ages even this little fire may be quite extinct, and then no other sign thereof may be left but a prodigiously high Rock or spiring Mountain, which in tract of time may by degrees waste and be diminished into a Hill of a more moderate height.

Now as this Hill seems very evidently to be the effect of an Earthquake, so I am apt to believe that most, if not all, other Hills of the world whatever may have been the same way generated. Nay, not only all the Hills, but also the Land which appears above the face of the waters. And for this I could produce very many Histories and Arguments that would make it seem very probable, but that I reserve them in the Lectures which I read of this subject in *Gresham* Colledge in the years 1664, and 1665, which when I can have time to peruse I may publish.

Therein

Therein I made it probable that most Islands have been thrown up by some subterraneous Eruptions. Such is the Island of *Ascension*, the *Moluccas*, &c.

Secondly, that most part of the Surface of the Earth hath been since the Creation changed in its position and height in respect of the Sea, to wit, many parts which are now dry Land, and lie above the Sea, have been in former Ages covered with it; and that many parts, which are now covered with the Sea, were in former times dry Land. Mountains have been sunk into Plains, and Plains have been raised into Mountains.

Of these by observations I have given instances, and shewed that divers parts of *England* have in former times been covered with the Sea, there being found at this day in the most Inland parts thereof sufficient evidences to prove it, to wit, Shells of divers sorts of Fishes, many of which yet remain of the animal substance, though others be found petrified and converted into stone. Some of these are found raised to the tops of the highest Mountains, others sunk into the bottoms of the deepest Mines and Wells, nay, in the very bowels of the Mountains and Quarries of Stone. I have added also divers other instances to prove the same thing of other parts of *Europe*, and have manifested, not only that the lower and plainer parts thereof have been under the Sea, but that even the highest *Alpine* and *Pyrenean* Mountains have run the same fate. Many Instances of the like nature I have also met with in Relations and observations made in the *East* as well as in the *West Indies*,

Of all which strange occurrences I can conceive no cause more probable than Earthquakes and subterraneous Eruptions which Histories do sufficiently assure us have changed Sea into Land, and Land into Sea, Vales into Mountains sometimes, into Lakes and Abysses at other times; and the contrary — unless we may be allowed to suppose that the water or fluid

part of the earth which covered the whole at first, and afterward the greatest part thereof, might in many Ages and long process of time be wasted, by being first raised into the Atmosphere in vapours, and thence by the diurnal, but principally by the annual motion thereof be lost into the *aether*, or medium through which it passes, somewhat like that wasting which I have observed to be in Comets, and have noted it in my *Cometa*: Or unless we may be allowed to suppose that this fluid part is wasted by the petrification and fixation of such parts of it as have fallen on the Land and Hills, and never returned to fill up the measure of the Sea, out of which it was exhaled, for which very much may be said to make it probable that the water of the earth is this way daily diminished.

Or unless (since we are ascertained by observations that the direction of the Axis of the earth is changed, and grown nearer the Polar Star than formerly; that the Magnetism or Magnetical Poles are varied, and do daily move from the places where they lately were, and that there are other great and noted changes effected in the earth) we may be allowed to conceive that the Central point of the attractive or gravitating power of the earth hath in long process of time been changed and removed also farther from us towards our Antipodes, whence would follow a recess of the waters from these parts of the world to those, and an appearance of many parts above the surface of the water in the form of Islands, and of other places formerly above the Sea now in the form of Mountains, so to continue till by the libration or otherways returning motion thereof it repossess its former seat and place, and overwhelms again all those places which in the interim had been dry and uncovered with the return of the same water, since nothing in nature is found exempt from the state of change and corruption.

Further,

Further, it is probable that Earthquakes may have been much more frequent in former Ages than they have been in these latter, the consideration of which will possibly make this Assertion not so Paradoxical as at first hearing it may seem to be; though even these latter Ages have not been wholly barren of Instances of the being and effects of them, to convince you of which I have hereunto subjoyned a Relation and account of one very newly which hapned in the Isle of *Palma* among the *Canaries*.

Next, the clearness of the Air is very remarkable, which made an Island which lay eight Leagues off to look as if it were close by. To this purpose I have often taken notice of the great difference there is between the Air very near the lower Surface of the Earth, and that which is at a good distance from it; That which is very near the earth being generally so thick and opacous that bodies cannot at any considerable distance be seen distinctly through it: But the farther the eye and object are elevated above this thick Air, the more clear do the objects appear. And I have divers times taken notice that the same object seen from the top and bottom of a high Tower hath appeared twice as far off when seen at the bottom as when seen at the top: For the Eye doth very much judge of the distance of Objects according as the Density of the Air between the Eye and Object doth represent them. Hence I have seen men look of Gigantick bigness in a fog, caused by reason that the Fog made the Eye judge the Object much farther off than really it was, when at the same time the visible Angle altered not. This great thickness of the lower Air is sufficiently manifest in the Coelestial bodies, few of the fixt Stars or smaller Planets, being visible till they are a considerable way raised above the *Horizon*.

The third remark about the moistness of the fogs, and the production of water at that height I have be-

fore insisted on. Only the almost continual fogs that this Gentleman observed in the Wood they passed is very remarkable for the origine of Springs.

Nor shall I say any thing concerning the vast perpendicular height of the same, but for a close of this present collection I shall add the short account of the Eruption which lately hapned in the *Palma*.

A true Relation of the Vulcanos which broke out in the Island of the Palma Novemb. 13. 1677.

Saturday the thirteenth of November 1677. a quarter of an hour after Sun-set hapned a shaking or Earthquake in the Island of *St. Michael de la Palma*, one of the *Canary* Islands, from the lower *Pyrenna*, and within a League of the City unto the Port of *Tassacorte*, which is accounted thirteen Leagues distant along the Coast, but more especially at or about a place called *Fuencaliente*, being seven Leagues from the Town to the Southwards. The trembling of the earth was observed to be more frequent and violent than elsewhere, and so it continued till *Wednesday* the 17. *ditto*. The People thereabouts were much affrighted, for besides the Earthquake there was often heard a thundring noise as in the bowels of the earth on a Plain called the *Canios*, which is before you come to the great descent towards the Sea, where the hot Baths stand; or the holy Fountain; likewise at the ascent from the aforesaid Plain upwards at the great and wearisom Hill, called *Cuesta Cansada*, and until the Mountain of *Goatyards*, and the same day in and about the said places mentioned, the Earth began to open several mouths, the greatest of them upon the said *Goat* Mountain, being distant from the Sea a mile and an half, and from the said opening came forth a very great

great heat and smell of Brimstone; and the same day, an hour before Sun-set at one of the mouths of the wearisom Hill was a trembling thereabout with more violence than any of the four days before; and a great and black smoak came forth with a terrible thundring noise, opening a very wide mouth, and throwing out much fire, with melted Rocks and stones; and immediately after at another place eighty paces below hapned the like terrible noise and sight, and in less than a quarter of an hour after there opened to the quantity of eighteen mouths towards the foot of the said Mountains, and there issued out fire, melted Rocks, and other bituminous matter from all the said mouths, and was presently formed into a great River of fire, which took its course over the first mentioned Plain, slowly going down towards the said holy Fountain; but it pleased God, being come within eight spaces of the Brink of the said great descent, it turned a little on the right side, and took its course with a very great fall towards the old Port, which is that which was first entred by the Spaniards when they took the Islands.

Friday the nineteenth at two a clock in the afternoon in the aforesaid Mountain of Goats, on the other side of *Tassacorte*, there opened another mouth with much smoak and stones of fire, and so closed again. But the next day (the twentieth) it began again to smoak, and continued with great trembling and noise in the bowels of the Earth until *Sunday* the twenty first at noon, when with many flashings of fire, and a greater thundring noise it finished that opening of that monstrous birth, casting up into the Air both fire and stones, and at night the smoak ceasing, the thundring noise, fire and stones increased, forcing great fiery stones so high into the Air as we lost sight of them, and with such violence sent them upwards that according to the best judgment they were five times longer in falling down,

which stones or Rocks were observed to be bigger than a Hoghead, ; and what was most to be admired was, that these breaking in the Air, and changing into many several shapes, distinctly appearing, yet notwithstanding did reunite again in falling down.

Monday the twenty second it began again to cast forth black smoak for two hours time, and after to thunder, and throw up fire and stones with great violence. *Tuesday* the twenty third at noon it smoked again, and from thence until night there was terrible thundring noise, and casting up of fire and stones more fierce than before ; and about nine of the clock at night a very great trembling of the earth was felt, and presently after followed three great stones of fire in the form of Globes which were forced about half a League in height, and then like Granadoes broke in the Air with very great noise. *Wednesday* the twenty fourth it was for an hours time very quiet, and after it began with greater force than ever before, by reason that some of the lower and first mouths were partly stopt, with which the aforesaid River of fire ceased from running, after it had dammed up the Bay of the old Port, with burnt and melted Rocks and Stones, and other matter wherewith the said River had run, and had forced the Sea backward above a Musquet shot at random, and near twice as much in breadth. It ran into the Sea above sixty paces. What fell into the Sea went congealing with a great smoak, what came after, forced and ran over that which went before, so that the smoak was very great many paces within the Sea, as far as seven fathoms depth, which caused many men to imagine that some such like *Vulcano* had opened under the Sea in the said seven fathoms depth. This night it cast up some stones like great fiery Globes as the former.

Thursday the twenty fifth it proved yet more violent than ever with thundring noise and flashes of fire.

fire. *Friday* the twenty sixth, the mouth that was at the foot of the Mountain began again to cast up as much fire and stones as ever, and formed two other Rivers; the one taking its course to Leeward of the first River leading toward the Rocks called *de los Tacosos*; and the other took its way to windward of the first, directly towards the Bathes or Holy Fountain; and in this entrance the mouth of the Mountain was observed to be more quiet, though it cast up much ashes like black small sand. What damage appears to have been done from its beginning to this day the twenty sixth of *November*, being of thirteen days continuance, hath been about nine or ten Country Houses burnt, besides Out-houses, and great Cisterns for water, which are the poor Peoples only Remedy in those parts, and upwards of three hundred Acres of ground are quite spoiled, being covered with Rocks, Stones, and other Rubbish and Sand; and if, (which God defend) the said *Vulcano* do longer continue, the damage must be far greater, especially if any other mouth should break out higher, as it is much feared, by reason the earth in some places doth open with appearances as at first, so that all about that circuit of the *Fuencalliente* will be lost; and for what already hapned, and yet continues with much terrour, besides the fears of more in other parts thereabout, the Inhabitants do leave their Habitations, and like poor distressed people seek relief at the City, and many leave the Island to seek their fortunes in the others.

From the twenty sixth of *November*, that the aforesaid Relation was sent for *Teneriff* by the Chamber of this Island unto the General, the said *Vulcano* continueth fierce and without ceasing, rather more than less, with a terrible thundring noise, casting up Fire, Stones, Rocks, and black Ashes, and the three Rivers of Fire still running into the Sea, and hath now dammed up all the Baths and holy Fountain, to
the

the great detriment of the Island, that yearly received a great benefit thereby, besides many damages daily added to the former. Several other mouths have since opened in the like dreadful manner near about the same place, we see the great smook by day, and hear the thunder and noise, like the shooting off of many Cannons, and by night see also much of the fire very high in the Air from this City, which is one and twenty miles from it.

We are now at the eleventh of *December*, and fear we shall have more to write to you by the next.

Other Letters of the thirtieth of *December* mention, that it then continued much at one as before; and since others of the nineteenth of *January* say, it is yet as dreadful as ever, and little likelihood of ceasing; from the thirteenth of *November* that it began to the nineteenth of *January* is about ten Weeks that it hath burnt; and the last Letters mention abundance of Ashes or black Sand forced into the Air, and carried all over the Island, falling thick like Rain, and frequently gathered in the City, in the Streets, Houses, and Gardens, though seven Leagues off.

FINIS.

ERRATA.

PAge 10. line 15. read the other, viz, the vibrating. l. 16. participates. l. 17. & 18. r. Vibration thereof, but all Solids do exclude that medium, or participate not of its motion. p. 14. l. 11. for length r. number. l. 12. r. occasions will be. p. 15. l. 6. r. LMN O. l. 12. r. have of Elasticity. l. 18. l. 29. r. equal to ten. p. 42. l. 12. r. from *Oraxava*. l. 12. r. or South-east side. p. 42. l. 9. for Francis r. Francis.

